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Volume 23, Tower-Perturbation Measurements in Above-Water Radiometry

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ABSTRACT

This report documents the scientific activities which took place during June 2001 and June 2002 on the *Acqua Alta* Oceanographic Tower (AAOT) in the northern Adriatic Sea. The primary objective of these field campaigns was to quantify the effect of platform perturbations (principally reflections of sunlight onto the sea surface) on above-water measurements of water-leaving radiances. The deployment goals documented in this report were to: a) collect an extensive and simultaneous set of above- and in-water optical measurements under predominantly clear-sky conditions; b) establish the vertical properties of the water column using a variety of ancillary measurements, many of which were taken coincidently with the optical measurements; and c) determine the bulk properties of the environment using a diversity of atmospheric, biogeochemical, and meteorological techniques. A preliminary assessment of the data collected during the two field campaigns shows the perturbation in above-water radiometry caused by a large offshore structure is very similar to that caused by a large research vessel.

Prologue

Ocean color satellite sensors (IOCCG 1998) provide large-scale synoptic observations of biogeochemical properties of the upper layer in the open ocean (e.g., phytoplankton biomass), as well as continuous monitoring of other important parameters in the coastal zones (e.g., sediment load and dissolved colored matter). This global capability is accomplished through the determination of radiometric quantities, specifically the spectral values of the radiances at the top of the atmosphere, from which (after atmospheric correction), the radiances emerging from the ocean surface, $L_W(\lambda)$, the so-called *water-leaving radiances*, are extracted (λ denotes the wavelength).

For meaningful applications, an extremely high radiometric accuracy is required. The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project, for example, requires accuracies of 5% absolute and 1% relative in terms of the retrieved $L_W(\lambda)$ values (Hooker and Esaias 1993). The first obvious condition for reaching such an accuracy lies in the conception and the realization of the spaceborne instrument. Although this is a necessary requirement, it is not sufficient to ensure the distributed radiometric data meet the accuracy objectives. Indeed, the success of the SeaWiFS mission is determined in particular by the quality of the ocean color data set collected for calibration and validation purposes, and involves several continuous activities (McClain et al. 1992):

1. Characterizing and calibrating the sensor system,
2. Analyzing trends and anomalies in the sensor performance and derived products (the L_W values and the chlorophyll concentration),
3. Supporting the development and validation of algorithms (for the retrieval of bio-optical properties and for atmospheric correction), and
4. Verifying the processing code and selecting ancillary data (e.g., ozone, wind, atmospheric pressure) used in the data processing scheme.

The initial SeaWiFS validation results (Hooker and McClain 2000) provided an immediate and quantitative demonstration of the strengths of the initial calibration and validation plan (McClain et al. 1998): a) the sensor was stable over the first two years of operation, with gradual changes in some wavelengths being accurately quantified using the solar and lunar calibration data; b) the vicarious calibration approach using field data produced consistent $L_W(\lambda)$ values; and c) the remotely-sensed products, including the (total) chlorophyll *a* concentration, met the desired accuracy (35% over a range 0.05–50 $\mathrm{mg\,m^{-3}}$) over a limited, albeit diverse, set of open-ocean validation sites.

The study presented here does not deal with all aspects of the calibration and validation process. It is restricted to those field measurements suitable for vicarious calibration, as well as the derivation or improvement of bio-optical algorithms. Historically, the fundamental radiometric quantities selected for comparison with the radiances retrieved from the spaceborne sensor, were the upwelled spectral radiances just above the sea surface, $L_W(0^+,\lambda)$ (the symbol 0^+ means immediately above the surface). A variety of normalizations of these radiances are needed to render these quantities less dependent on the circumstances (in particular, on the solar illumination conditions prevailing when the measurements are performed), and thus to obtain more fundamental quantities to be introduced into the bio-optical algorithms.

The $L_W(0^+,\lambda)$ radiances can be derived by extrapolating in-water measurements taken close to the sea surface or obtained directly from above-water measurements. Although the SeaWiFS Project has placed an emphasis on in-water techniques, which have been largely successful in Case-1 waters (Hooker and Maritorena 2000), both measurement approaches have advantages and difficulties.